Smiths Detection mm-wave person imager

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Company proprietary Information

Summary

- Detection of threats/explosives carried on the body surface
- eqo™ scanner delivers automatic detection of threats/explosives carried on the body
- Active focussed real time imaging @ 24 GHz
- Video rate (14 fps)
- Open setup with small footprint
- No moving parts
- Next generation system:
  - Pass through operation mode
  - Uncooperative screening of persons
  - Anomaly detection → material classification based on ε_r

Mission

Threat Detection:

- Metallic Weapons
- Non-metallic Weapons
- Explosives
  - Commercial
  - Military
  - HMEs
  - Liquids
- Drugs

eqo™ Technical Specification

- Operational frequency: 24 GHz
- Scan volume: 1.1 m x 1 m x 2 m
- Small Footprint
- Focussed Imaging
- Frame rate: 14 frames per second
- Passenger turn through 360°
- Simple touch screen interface for screeners
- Automatic localization of threats

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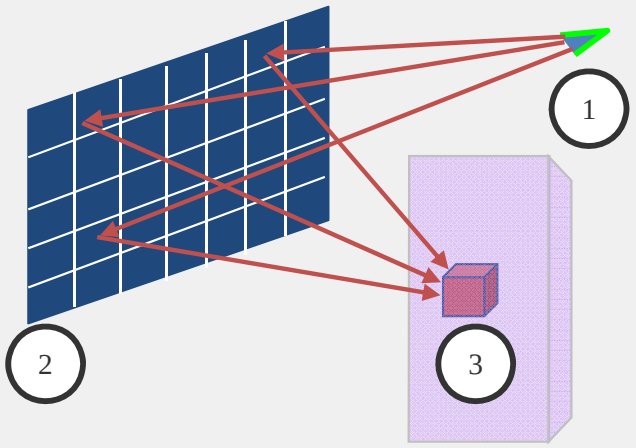
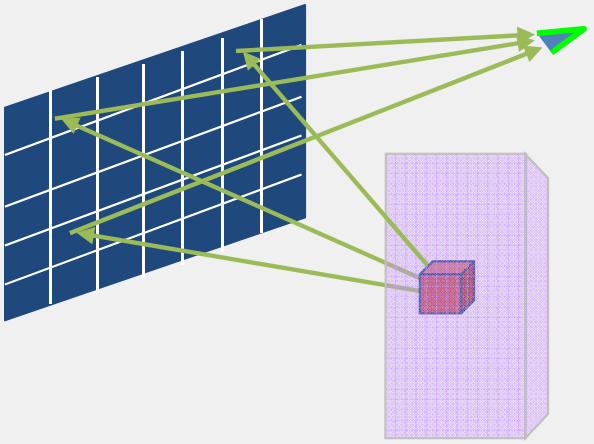
eqo™ Fresnel Lense

- The imaging system components
  - Transceiver (1)
  - Reflector Panel (2)
- The system emits a continuous wave (CW) radar signal from (1) towards the reflector panel (2).
- This forward signal is reflected and steered towards a volume in the scan space (3).
- If the signal encounters a reflector (person) in the scan volume, it will be reflected.
- Upon reaching the reflector, this signal is reflected back to the transceiver
- The forward signal is steered towards all points in the scan volume.
- Reflected signals are captured at the transceiver and processed to render an image.

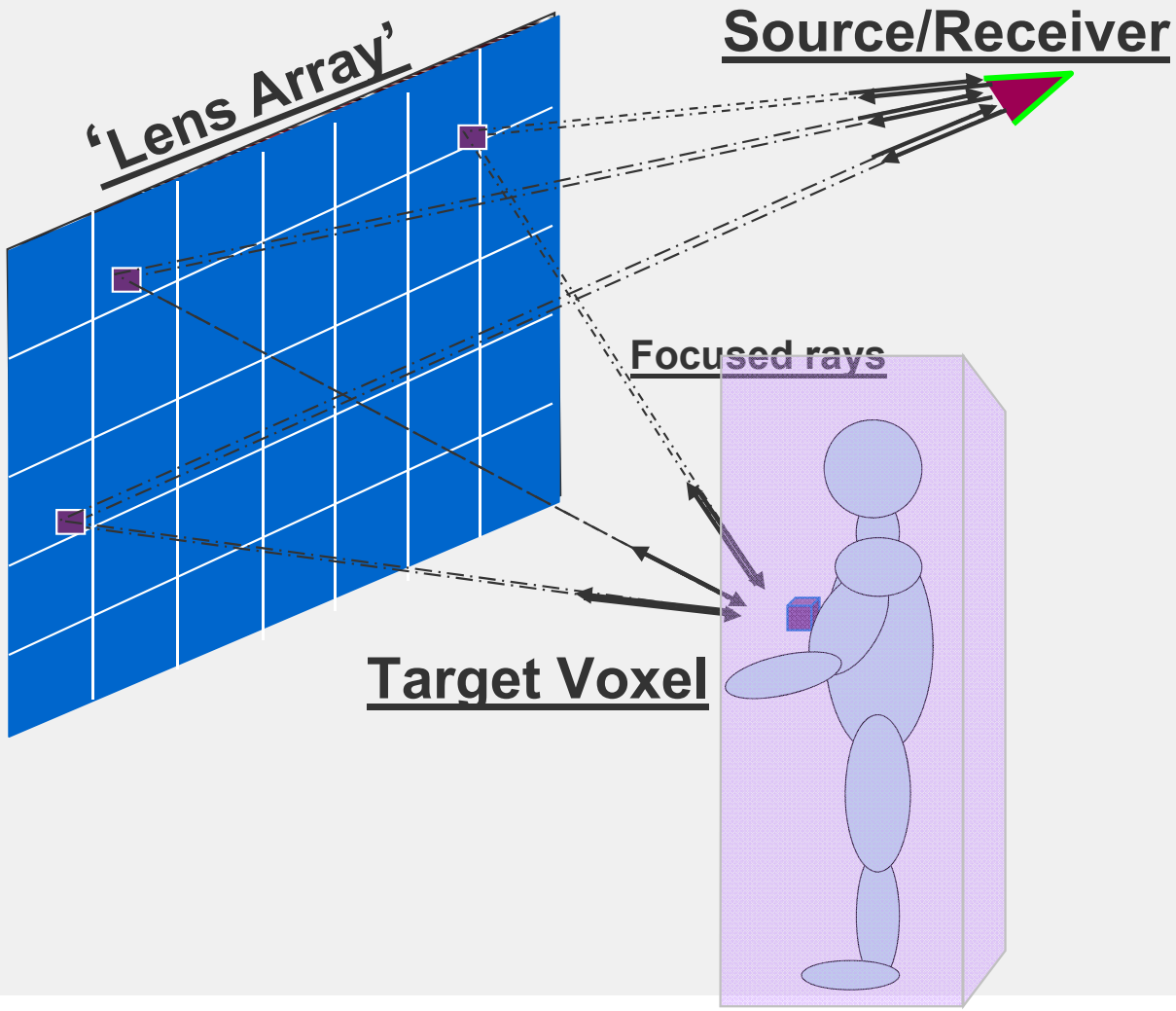


Forward Signal Path



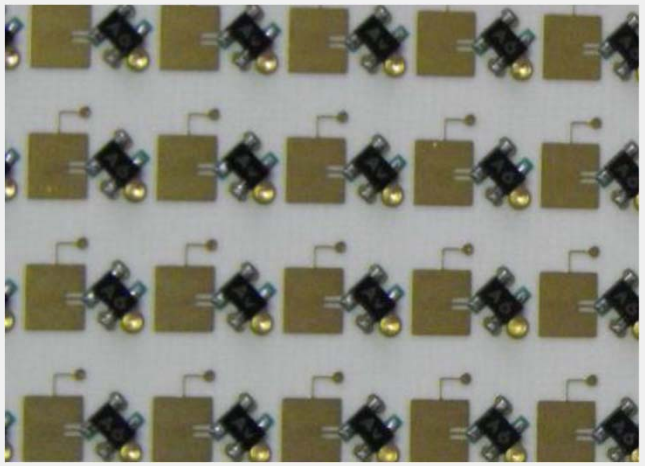
Return Signal Path

eqo™ Scanning Procedure



Reflector Array

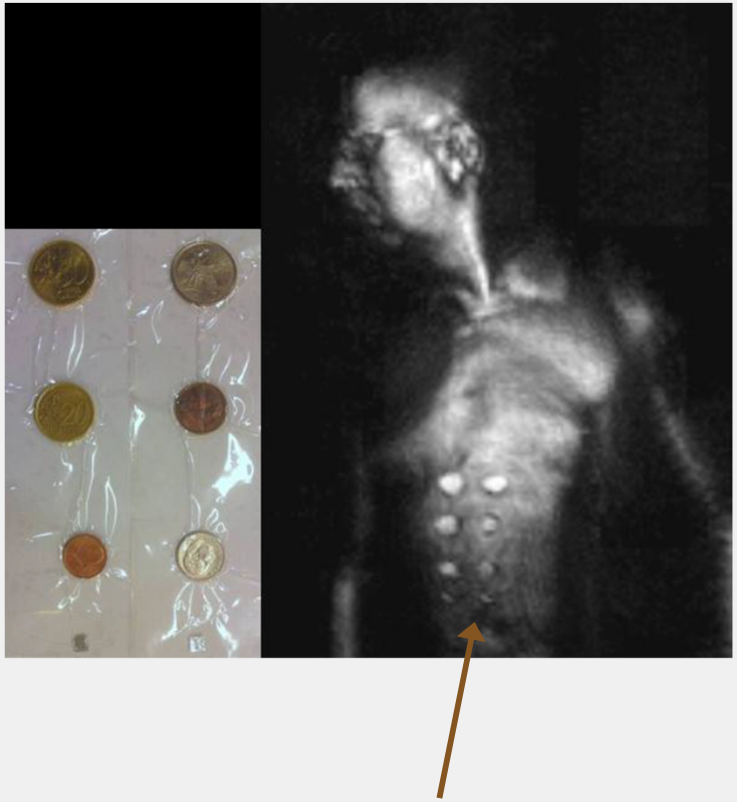
- The reflector-array modifies an incident wave front to achieve a particular reflected beam pattern.
- Reflector panel is composed of micro-strip patch antenna based reflector-arrays.
- Each antenna is paired with low-noise FET
- Steering is achieved through the binary phase approximation and constructive interference
    - Each antenna reflects the signal in phase (0 degrees) or out of phase (180 degrees)
    - The reflect-array acts as an elliptical mirror ensuring constructive interference.



Reflector Panel Array Elements with FETs

Image Capture Methodology

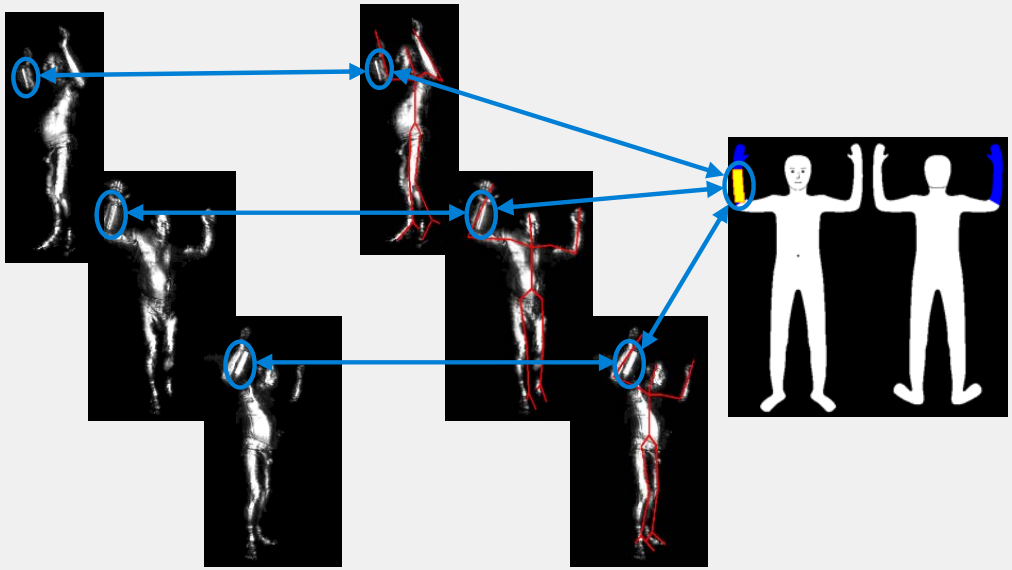
- Data is captured in each scanning volume throughout the active area
- Once the volume has been scanned, an image is rendered and sent for processing
- Capture and process continues while the subject makes a 360º turn in the scan volume.
- The image views are pieced together to produce a video-like rendering of the subject making the turn.
- The image dataset, system configuration, and background parameters are used as inputs to the image processing and detection processes
- Image resolution approximately 1 mm to 2 mm in each direction

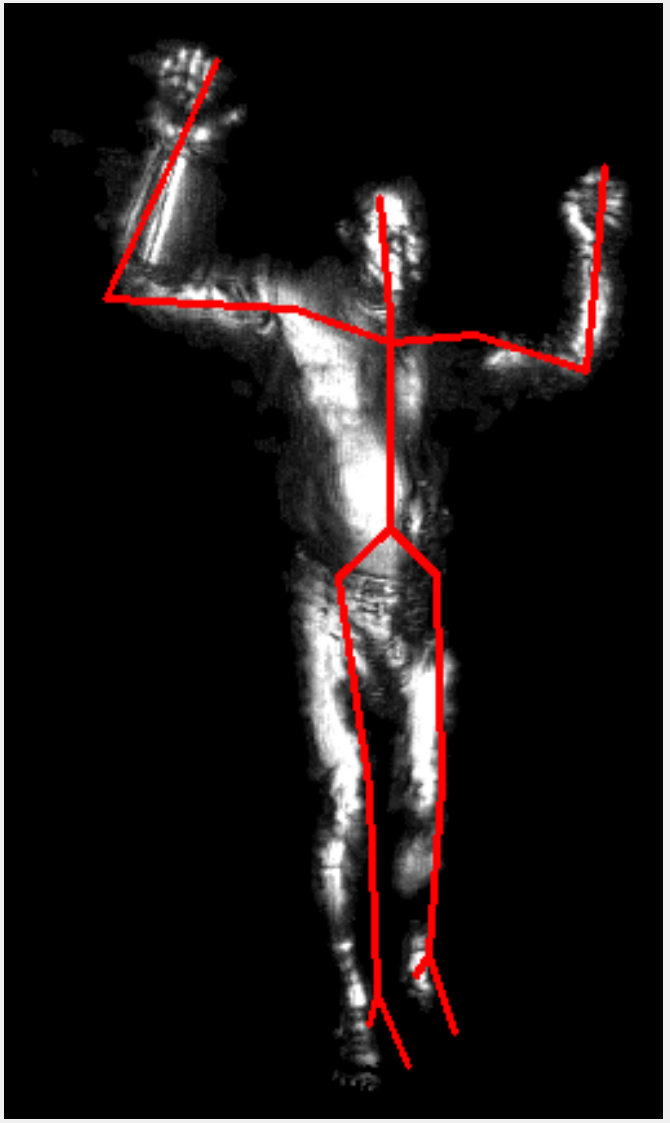


The 4mm x 4mm metal test reflectors are clearly seen in the image, indicating that the fundamental resolution is at or below this level

ATR: 3D Body Model

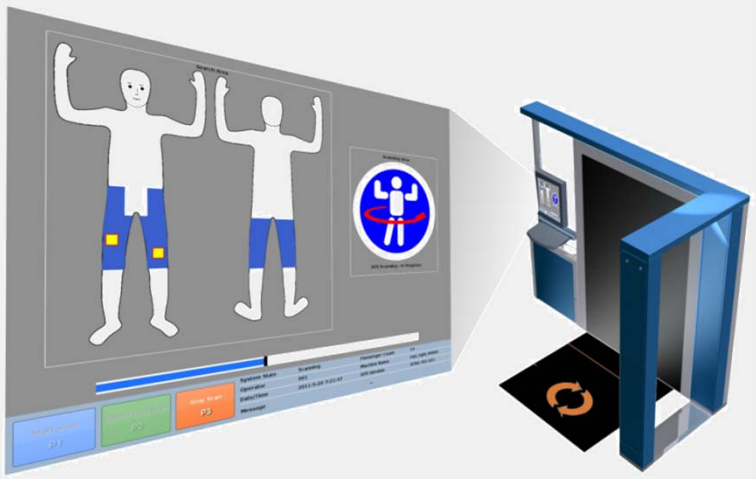
- Identify anomaly objects in the various views
- Map objects to the correct location on the representative human figure.
- Account for threat objects that look different depending on body region and concealment
- Suppress typical false alarms on body regions





Automatic Threat Recognition (ATR)

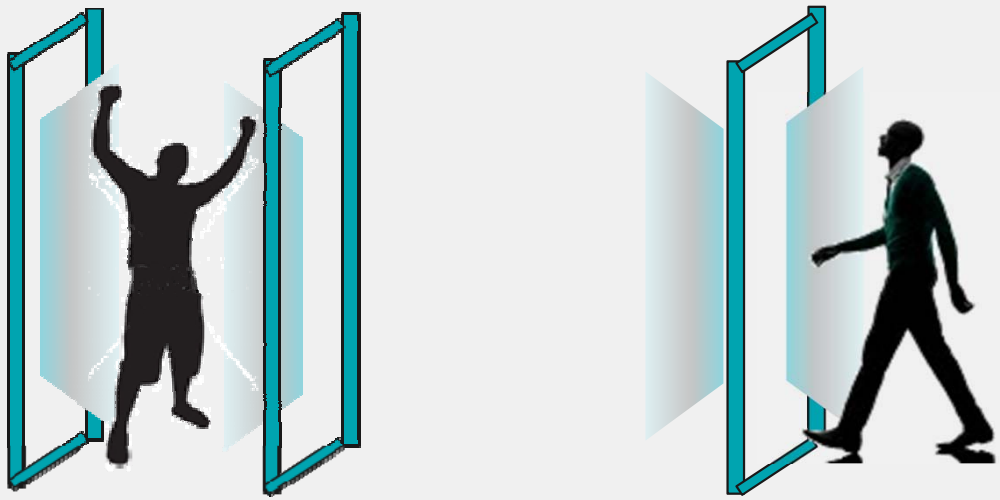
- ATR algorithms locate and annotate suspected threat or contraband items.
- ATR addresses privacy concerns by removing image display and user analysis
- The eqo ATR algorithms examine the source video sequence to detect items in real time
- Result latency is less than one second
- Detection results are displayed on two “avatar” views of a human body
    - Suspicious regions are indicated by a rectangular box on the avatar in the location of the anomaly
    - Secondary search is directed at the location of the threat indicators



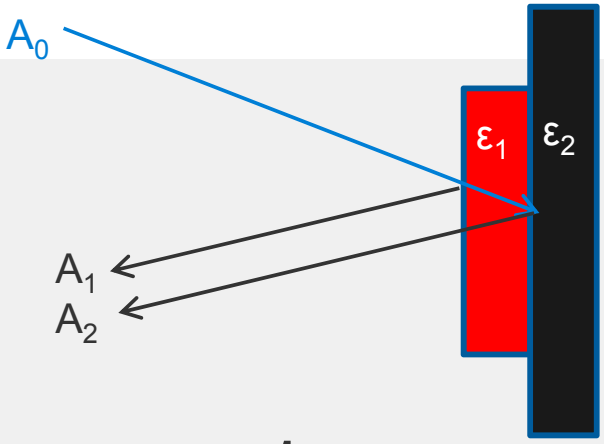
Next generation CONOPS

Pass Through Operation:

- Open chamber assembly
- Imaging of person while entering and leaving
- Posing required at the centre only
- Larger footprint



Material classification via ε_r estimation



Assumption:

- parallel plane reflection
- lossless transmission
- No frequency dependence

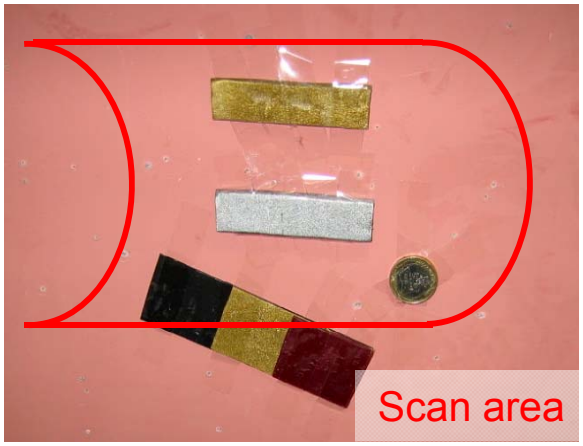
$$d_{Obj} = d_{Air} \times \sqrt{\varepsilon_r}$$

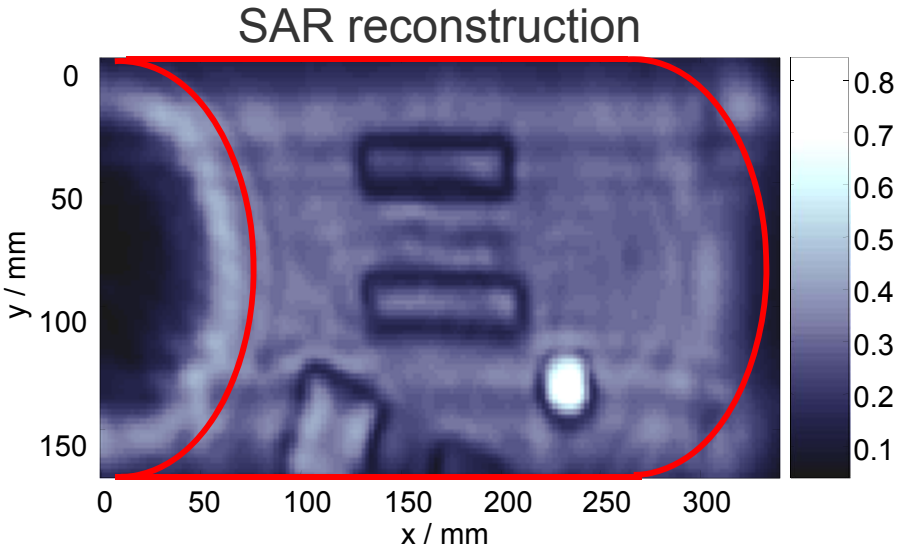
Prerequisite:

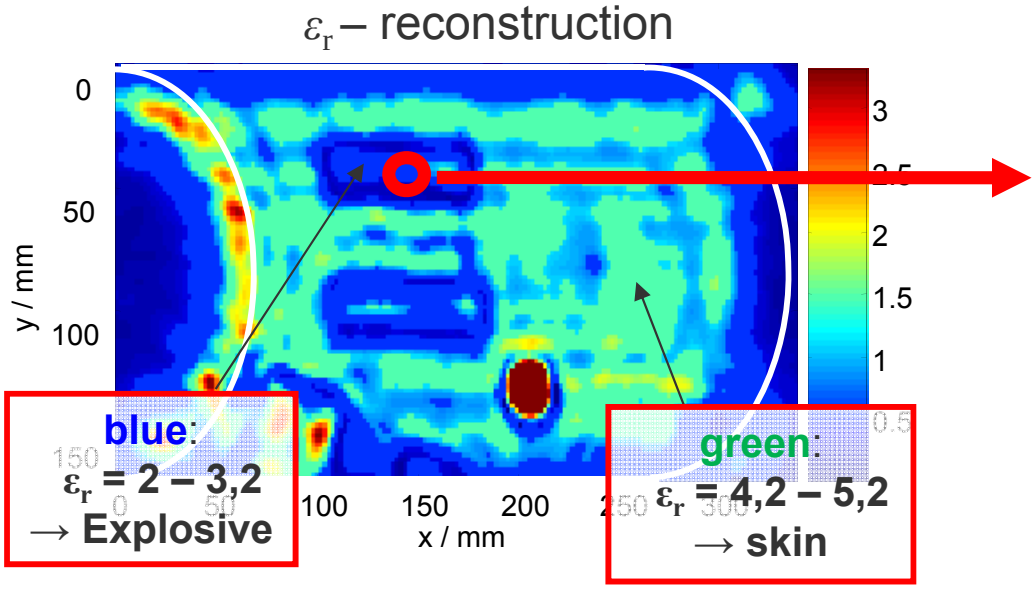
- precise determination of reflection plane ⇨ object thickness
- Optical path length difference

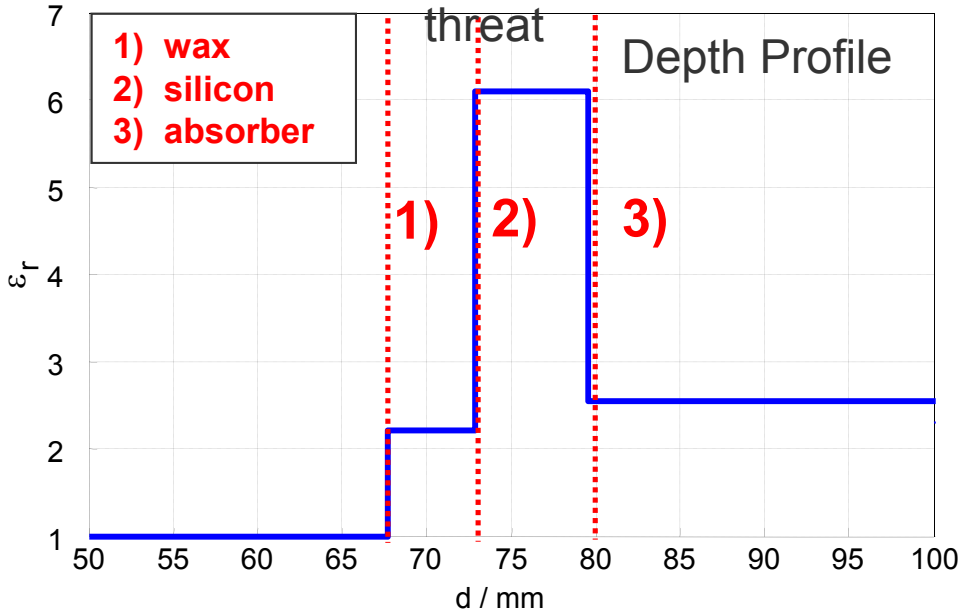
ε_r Determination (SAR measurement) *

Scenario:
wax stripes, coin on silicone (covered by clothes – not shown in the photo)









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* Work performed in cooperation with Univ. Erlangen

Technology

Higher Frequency:

- Increased image resolution
- Potential to do ε_r classification
- Stronger contribution of clothing in the image
- Increased amount of data
- Higher complexity

Increased bandwidth:

- Regulation issues
- Technological challenging

Summary

- Detection of threats/explosives carried on the body surface
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- active focussed real time imaging (24 GHz) at video rate (14 fps)
- Open setup with small footprint
- No moving parts
- Next steps:
  - pass through operation mode at same cost
  - uncooperative screening of persons
  - Material classification based on ε_r

THANK YOU

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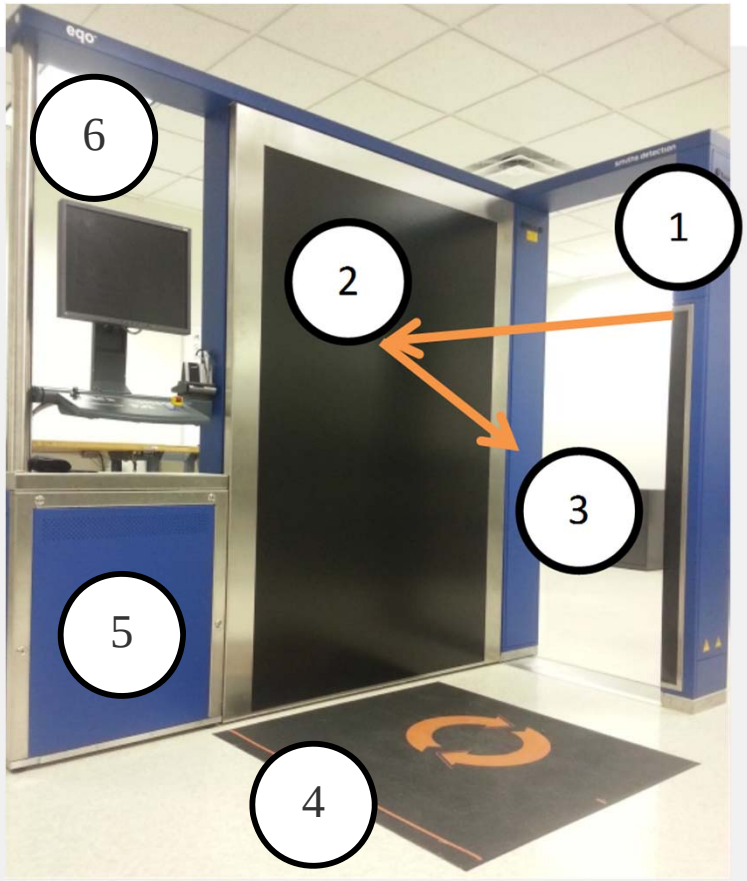
eqo™ Realization

- Operates at a nominal frequency of 24 GHz
  - Industrial, Scientific and Medical (ISM) band
  - Clothing is essentially transparent
  - Minimal scatter from seams, stitching, and folds.
  - Body is very reflective
  - Dielectric materials show up well against the body.
  - Signals sufficient for resolution requirement
- Scan volume: 1.1 m by 1 m by 2 m
- Transceiver consists of a
  - 10 dB gain horn with integrated circulator
  - phase locked transmitter
  - receiver w/ phase locked Local Oscillator (LO).

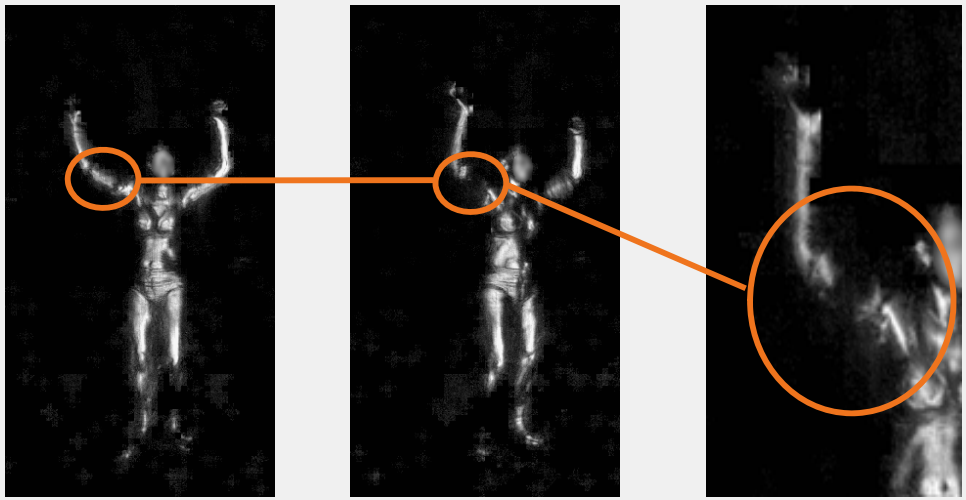


1. Signal source and receiver
2. Reflector panel
3. Scanning volume
4. Signal illumination footprint
5. Computer and data storage

Image Capture Methodology: CONOPS

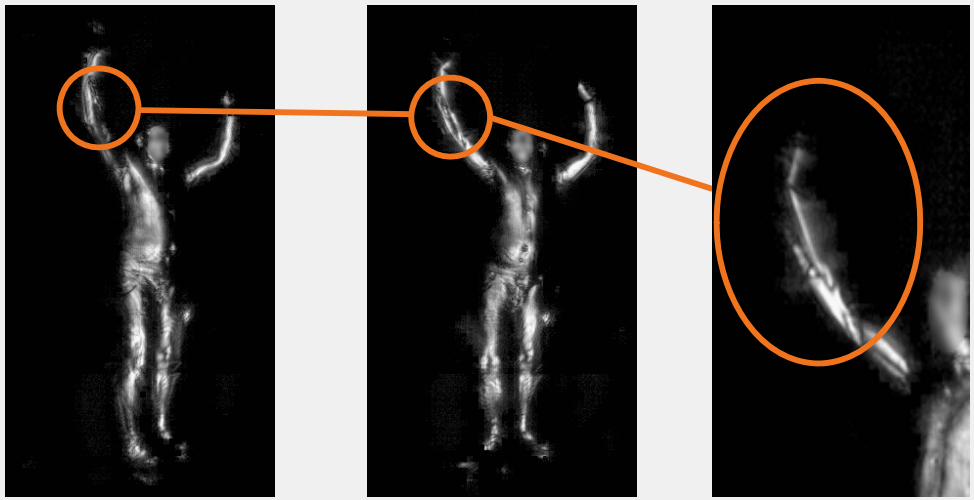
- Passengers turn through 360°
- Simple touch screen interface for screeners

ATR: The Science Behind the Turn (1 of 2)



Reflective threat concealed on the upper arm

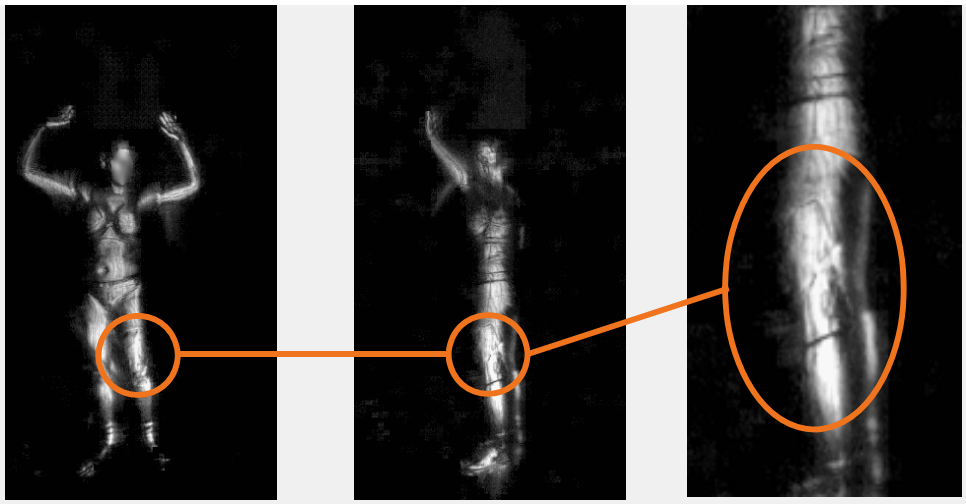
Object detected with non-uniform properties



Concealed knife visible when the person rotates

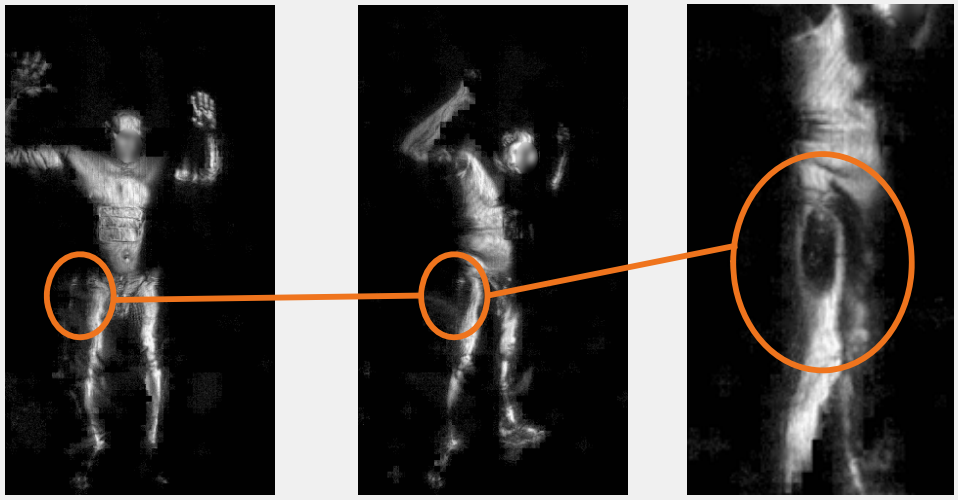
Concealment defeated by turn CONOPS

ATR: The Science Behind the Turn (2 of 2)



Contoured threat visible with angular movement

Concealment defeated by motion of the passenger



Concealed bulk threat visible when the person rotates

Concealment defeated by collection of side view with full 3-D dataset

Next Generation mm-wave Imager

Goal of future development:

- CONOPS:
  - walk through operation
  - uncooperative data recording
- Detection:
  - anomaly detection ⇨ material classification
  - enhanced resolution
- Technology:
  - higher frequencies
  - increased bandwidth
  - SAR based imaging or unfocussed imaging